Back to Basics

BY REBECCA ELLIS AND HOWARD MCKEW

TEST 9 — CHILLED-WATER SYSTEM USING CENTRIFUGAL CHILLER, ADVANCED ENERGY-EFFICIENT DESIGN

Choose the correct answer (from the choices in bold) for each of the following hvac situations, referring to the schematic diagram on this page.

On-off control in the "off" position:
Centrifugal chiller CC-1 is (on, off), primary chilled-water pump P-1 is off, secondary chilled-water pump P-3 is off, condenser water pump P-2 is off, and "draw through" cooling tower fan is off.

On-off control in the "on" position:
CC-1's on-off switch at the unit control
panel CP-1 is placed in the "on" position, but the refrigerant process does
not start. Interlock (control, power)
signals from chiller control panel CP-1,
to chilled-water pump P-1 and P-3 and
condenser water pump P-2. Start all
three pumps. Chilled-water flow switch
FS-1 senses flow and confirms P-1 is
delivering sufficient flow for CC-1 to
start. Condenser water flow switch FS-2
senses flow and confirms P-2 is deliver-

ing sufficient flow for CC-1 to start. CC-1 centrifugal refrigeration cooling process begins.

On-off control in the "on" position:
With chilled-water flow, system pressure will begin to increase and differential pressure transmitter DP-1 shall begin to control the secondary chilled-water flow via variable-speed drive VSD-1 (sequence noted below). Chilled-water supply temperature control transmitter (TT-1, TT-2), set at 45 F, shall maintain supply water temperature set-

point by modulating the chiller CC-1 self-contained centrifugal refrigeration controls within control panel CP-1.

On-off control in the "on" position:
Condenser water supply temperature control transmitter TT-2, set at 85 F, shall maintain supply water temperature setpoint by (starting, stopping) cooling tower fan CT-1, controlling fan speed via variable-speed drive VSD-2, and stopping fan CT-1. On a rise in condenser water supply temperature, 3 F above 85 F, CT-1 fan shall start at (low, normal, high) speed. If condenser water supply continues to rise, fan speed will increase towards maximum airflow via VSD-2. When condenser water temperature drops towards 85 F, CT-1 fan shall reduce speed and stop when condenser water supply temperature drops below the 85 F setpoint.

Maximum cooling: Chiller CC-1 shall be providing maximum cooling capacity, and secondary chilled-water supply pump (P-1, P-2, P-3) shall be at maxi-

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mum flow via VSD-1 pump speed control. Air-handling units' straight-through chilled-water valves shall be open 100%, drawing off all the chilled water for space cooling and/or dehumidification needs. Cooling tower CT-1 fan shall be operating continuously.

VSD

6 Minimum cooling: Chiller CC-1 shall be

Chiller CC-1 shall be providing minimum cooling capacity, and secondary chilled-water supply pump P-3 shall be at (**minimum**, **normal**, **maximum**) flow via VSD-1 pump speed control. Air-handling units' straight-through chilled-water valves shall modulate toward the closed position, reducing the need for chilled water for space cooling and/or dehumidification needs. Unused primary chilled water shall be bypassed (**downstream**, **upstream**) of P-3 via chilled-water bypass loop to maintain sufficient chilled-water flow through CC-1. Cooling tower CT-1 fan shall be off.

Differential pressure control:

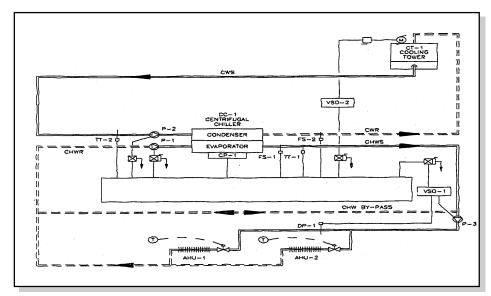
Variable-speed drive (**VSD-1**, **VSD-2**) shall control the pump speed of P-3 based on a differential pressure-control transmitter signal that senses variations in chilled-water system pressure. Starting at low speed, VSD-1 shall allow P-3 flow to (**decrease**, **increase**) based on a need to increase system pressure. When chilled-water supply pressure exceeds the DP-1 setpoint (in psig), P-3 shall begin to reduce speed via VSD-1.

If you have any questions regarding the Advanced Energy-Efficient Design — Commissioning test, send your concerns, questions, and/or comments to: Rebecca Ellis, P.E., 612-546-0494 (Fax); rellis@sebesta.com (e-mail).



TEST 10 — CHILLED-WATER SYSTEM USING CENTRIFUGAL CHILLER, ADVANCED ENERGY-EFFICIENT DESIGN — COMMISSIONING

Choose the correct answer (from the choices in bold) for each of the following hvac situations, referring to the schematic diagram on this page.



- Turn chiller off at CP-1 and verify that: a) All three pumps are (off, on).
- b) Chiller refrigerant system stops (before, after, at the same time as) the pumps.
- c) The cooling tower fan is off.
- Turn chiller on at CP-1 and verify that:
 - a) P-1 starts, P-2 starts, and P-3 starts at (minimum, maximum) VSD-1 speed.
 - b) Chiller refrigerant system starts after (FS-1, FS-2, FS-1 and FS-2) prove water flow.
- Increase chilled-water system differential pressure setpoint at DP-1 to 5 psi greater than current DP-1 reading and verify that: a) (VSD-1, VSD-2) increases speed to achieve new setpoint differential pressure.
- Decrease chilled-water system differential pressure setpoint to 5 psi less than the current DP-1 reading and verify that:
 a) VSD-1 slows pump (P-1, P-2, P-3) speed to achieve new setpoint differential pressure.
- Return DP-1 setpoint to original value. Increase condenser water temperature setpoint to 10°F greater than current TT-2 reading and verify that:
 - a) The cooling tower fan (runs at maximum speed, modulates, stops).
- Decrease condenser water temperature setpoint to 2.5°F less than the current TT-2 reading and verify that:
 - a) The cooling tower fan starts at minimum speed as controlled by (VSD-1, VSD-2).
 - b) Variable-speed drive (increases, decreases) cooling tower fan speed to achieve new setpoint condenser water temperature.

ANSWERS FOR ADVANCED ENERGY-EFFICIENT DESIGN: 1.off; 2. control; 3. TT-1; 4. starting, low; 5. P-3; 6. minimum, upstream; 7. VSD-1, increase.

- Decrease condenser water temperature setpoint to 10°F below current temperature and verify that: a) VSD-2 operates at (maximum, minimum) speed attempting to achieve the new setpoint temperature at TT-2.
- Return condenser water temperature to original 85°F setpoint and verify that: a) System returns to normal operation.

If you have any questions regarding the Advanced Energy-Efficient Design test, send your concerns, questions, and/or comments to: Howard McKew, P.E., 978-887-1116 (fax); hmckew@sebesta.com (e-mail).

HELPFUL HINTS:

There can be a wide array of sequence of operations for a centrifugal chiller. A design engineer may consider the following:

- Primary-secondary chilledwater flow when using multiple chillers.
- A two-speed cooling tower fan CT-1 may be used in lieu of VSD-2 control.
- Adding a plate-and-frame heat exchanger in parallel with the chiller to provide "free cooling" during the heating season. Condenser water side will probably require some form of chiller head pressure control when using cold (50°F or less) condenser water. VSD cooling tower fan control will be a better choice over twospeed fan control.
- If the cooling tower is a blowthrough type tower, automatic damper control at CT-1 fan may need to be added to control the condenser water supply temperature.

The design engineer should pay special attention to additional energy-efficient design opportunities based on chiller manufacturer's literature. Refer also to the "Chilled-water Management" article (September 1994 Engineered Systems) for several other chiller selections noted in the Chilled Water Matrix of Opportunities chart